

Primary Frequency Response Stakeholder Education Part 2 of 2



Primary Frequency Response
Sr. Task Force
September 1, 2017

Primary Frequency Response Education Part 1 of 2

- **Technical**
 - Power System Fundamentals
 - Importance of Primary Frequency Response (PFR)
 - Terms used in association with PFR
 - Resource and load response to frequency
 - Governor droop and deadband
 - Area Control Error (ACE)
 - Automatic Generation Control (AGC)
 - Interactions between PFR and Ancillary Services
- **Operational**
 - Review control modes
 - Review desired versus observed response
 - Analysis of recent events/unit performance

- **Operational (continued)**
 - Reasons for inconsistent response
 - Changing technologies
 - Governor Survey observations
- **Importance of PFR During System Restoration (Blackstart)**
 - Frequency control during normal and restoration operations
 - Review governor modes of operation
 - Review restoration process
 - Reserves during normal and restoration operations

Primary Frequency Response Education Part 2 of 2

- **Current PJM Requirements**
 - Manual requirements
 - Tariff requirements

- **Regulatory activities related to PFR**
 - NERC BAL-003 compliance
 - NERC Frequency Response Initiative Report
 - NERC Advisory on Generator Governor Frequency Response
 - NERC Essential Reliability Task Force
 - FERC NOPR on Primary Frequency Response
 - ISO/RTO Council response to FERC NOPR
 - Additional NERC Activity
- **Glossary**
- **References**



Current PJM Requirements



- Manual 14D, Generator Operational Requirements
 - 7.1.1 Generator Real-Power Control
 - **All generators**, including pseudo tied or dynamically scheduled generating resources, should operate on unrestricted governor (or equivalent electronic speed control device) control to assist in maintaining interconnection frequency, **except for the period** immediately before being removed from service and immediately after being placed in service. **With exception of nuclear generators**, all generating resources with gross plant / facility aggregate nameplate rating **greater than 75 MVA** are requested to ensure that, in the absence of technical or operational considerations, the generator governor and Distributed Control System (DCS) settings provide **dead bands that do not exceed +/- 36 mHz**, and **droop settings that do not exceed 5%**. Should a generating resource be unable to meet these criteria, the generating resource's actual settings and reasons for being unable to meet these criteria shall be forwarded to PJM.

- Manual 12, Balancing Operations
 - 4.6, Black Start Service
 - 4.6.10 Performance Standards - The capability to maintain frequency under varying load. This may be demonstrated by
 - (a) picking up an isolated block of load, or
 - (b) by appropriate dynamic off-line testing of the governor controls.

- Manual 36 – System Restoration
 - 6.1 Generating Stations
 - Each generator's dispatch **cannot impede the full governor response** of the generator should a frequency decay occur. Otherwise, adjustments must be made to **Dynamic Reserve**. If a generating unit is loaded to maximum output, for instance, no governor response is available on that unit. In addition, units which have different operating ranges as a result of boiler configuration (i.e., placement of burners, etc.) **are not loaded to a point where the unit's operating limit impedes full governor response, if frequency decay occurs.**

- Manual 36 – System Restoration
 - 6.1 Generating Stations
 - Many generators in the PJM RTO are equipped with control systems primarily to **increase efficiency**. These systems may improve a generator's regulation capability in some cases; however, in a majority of cases, the **response to frequency decay is degraded**. The inherent characteristic of these control systems which contributes to degraded frequency decay response is the fact that turbine valve movement is **restricted by the boiler control** to avoid large pressure swings in the boiler. These control systems **negatively affect both the quality of regulation** on our system as well as the expected governor response of our system to large frequency deviations. **During system restoration, these governors must not be blocked and plant operators must operate the generator in a mode which allows the governors to respond to frequency.**

- Manual 36 – System Restoration
 - 6.1.7 Blocking Governors
 - During system restoration, **governors must not be blocked** and plant operators must operate the generator in a mode which allows the governors to **respond to frequency deviations** if this mode of control is available.

- PJM Tariff
 - Schedule 6A – Black Start Service
 - Performance Standards and Outage Restrictions
 - A Black Start Unit must be capable of maintaining frequency and voltage under varying load.
 - Attachment K, Appendix Section 1.11.1 – Resource Output
 - The Office of the Interconnection shall have the authority..... to balance load and generation, maintain scheduled tie flows, and provide frequency support within the PJM Region

NERC Standards & Regulatory Activity



- NERC Reliability Standard BAL-003-1
- NERC Frequency Response Initiative Report - The Reliability Role of Frequency Response
- NERC Industry Advisory – Generator Governor Frequency Response
- NERC Essential Reliability Task Force
- FERC NOPR – Third Party Frequency Response Service
- ISO/RTO Council response to FERC NOPR
- Additional NERC Activity

- Frequency Response and Frequency Bias Setting
- Applicable to PJM as the Balancing Authority
- Effective April 1, 2016
- Compliance is ongoing

Requirement 1: Each Balancing Authority shall achieve an annual Frequency Response Measure (FRM) that is equal to or more negative than its Frequency Response Obligation (FRO) ...



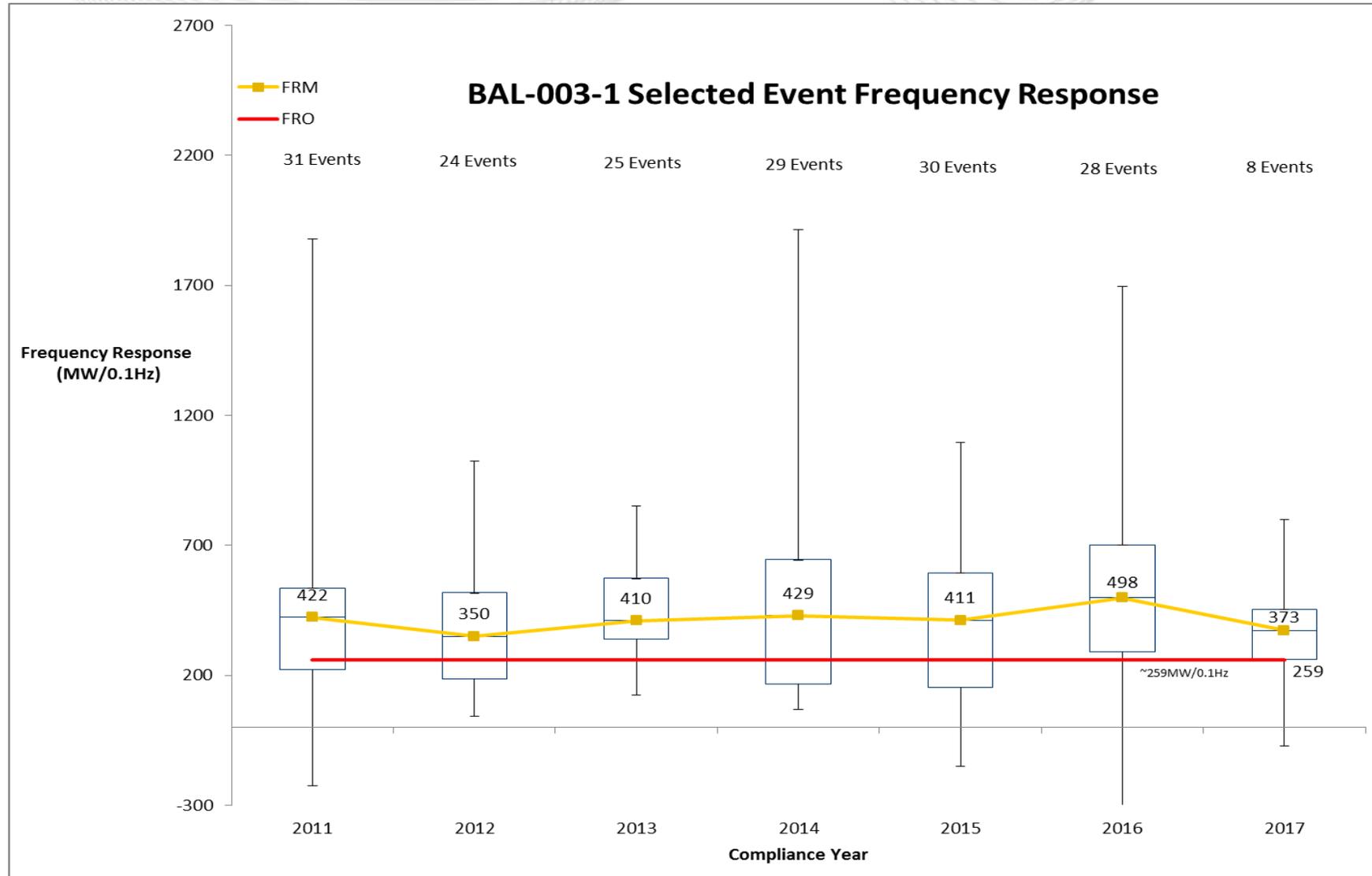
Balancing Authority FRO Allocation:

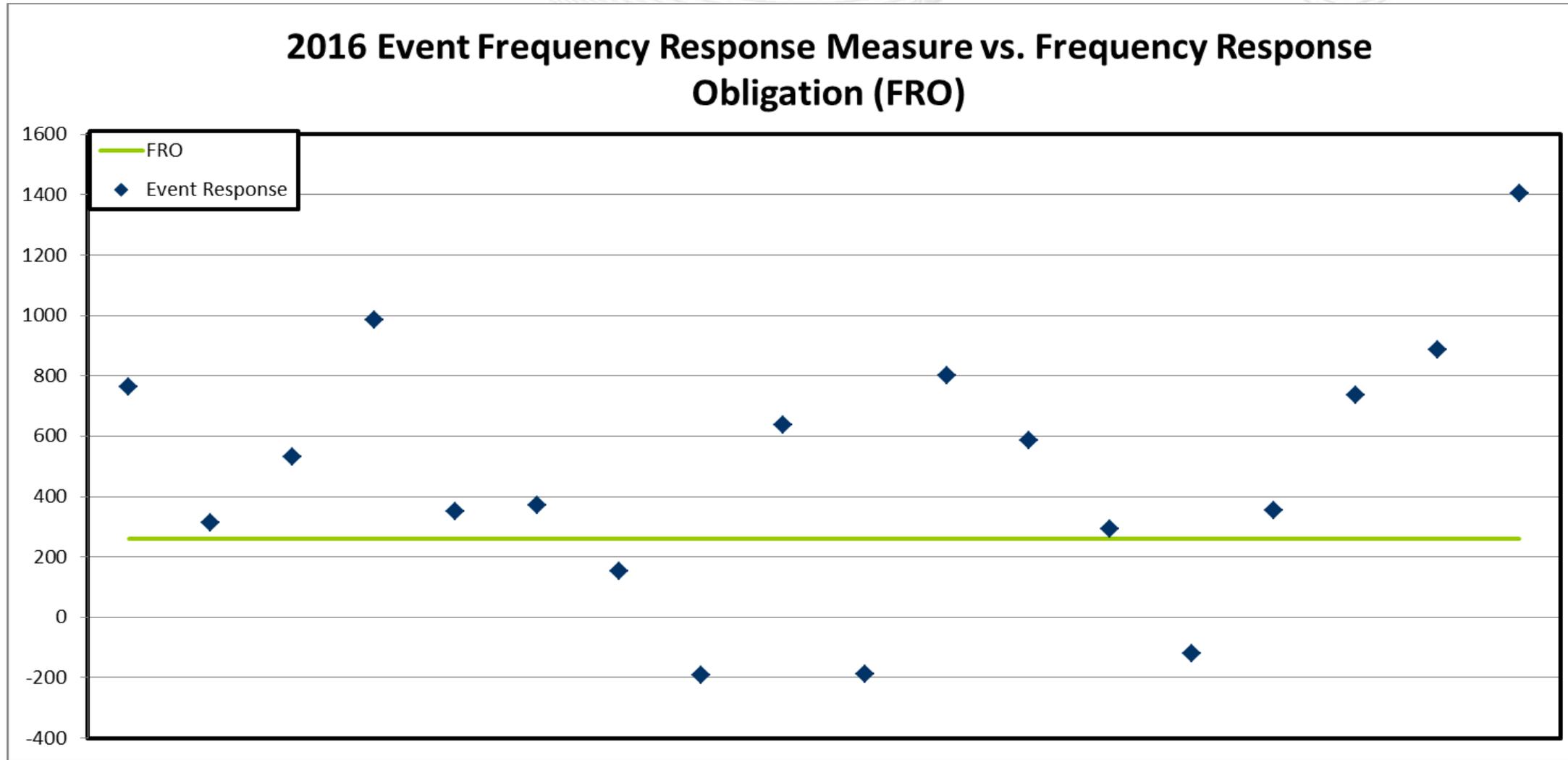
Interconnection Frequency Response Obligation x Balancing Authority Pro-rata Share

$$FRO_{BA} = IFRO \times \frac{\text{Annual Gen}_{BA} + \text{Annual Load}_{BA}}{\text{Annual Gen}_{Int} + \text{Annual Load}_{Int}}$$

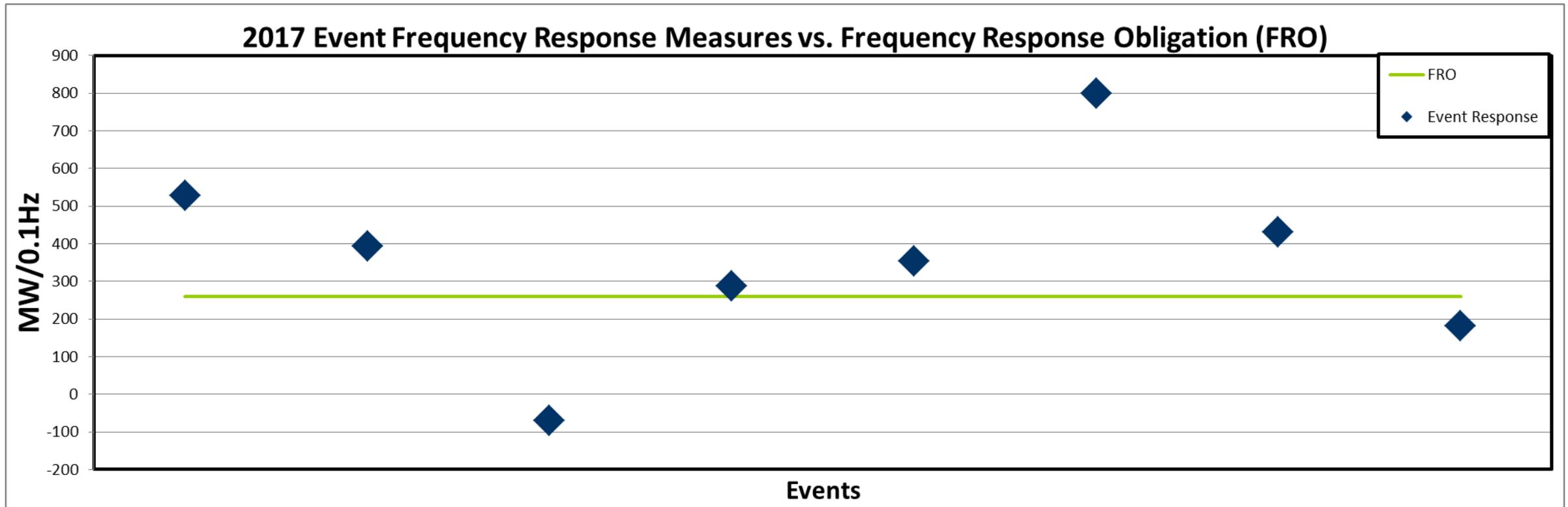
PJM FRO for 2017 operating year = (-1015MW/0.1Hz) x (25.44%) = -258.2 MW/0.1Hz
2017 Operating Year: December 2016 – November 2017

Performance is measured as the median of all NERC selected events; frequency response measured included generator governor response, & load response





- Events for 2017 Operating Year continue to show variability in Frequency Response



- Demonstrating the variability

Event	12/05/2015 17:31	03/02/2016 02:53:32
Response	-763.8 MW/0.1 Hz	-372.3MW/0.1Hz
Excursion	-0.055Hz	-0.054Hz
Response from Generation	-409MW/0.1Hz	-207MW/0.1Hz
Response in wrong direction	-157MW/0.1Hz	-128MW/0.1Hz

- From NERC Frequency Response Initiative Report, The Reliability Role of Frequency Response, October 2012 - Modeling of Frequency Response in the Eastern Interconnection
 - Only 30% of units on-line provide primary frequency response
 - 2/3 of the units that did respond exhibit withdrawal of primary frequency response
 - Only 10% of units on-line sustain primary frequency response
- Frequency Response in the Eastern Interconnection has improved since October 2012 however still observing many units not providing sustained primary frequency response

- [NERC INDUSTRY ADVISORY \(Issued February 5, 2015\)](#)
 - *“As a result of the Eastern Interconnection Frequency Initiative, the NERC Resources Subcommittee has determined that a significant portion of the Eastern Interconnection generator deadbands or governor control settings inhibit or prevent frequency response.”*
- Applicable to generating resources with gross plant / facility aggregate nameplate rating greater than 75 MVA excluding nuclear generators
- Governor dead bands not to exceed +/- 36 mHz, droop settings not to exceed 5%
- Governor settings & plant control algorithms should be coordinated to allow for primary frequency response
- Settings should be communicated to the Balancing Authority
- [Link to April 7, 2015 NERC Webinar on the advisory](#)

- NERC Essential Reliability Services Task Force Measures Framework Report, November 2015
- Objectives of the task force were to understand the power system behavior we have today, how this behavior may change in the future in light of the changing resource mix, what attributes we expect from resources in the future, and how to make the transition in a reliable way. The task force made general recommendations, including:
 - All new resources should have the capability to support voltage and frequency. Ensuring that these capabilities are present in the future resource mix is prudent and necessary.

- NERC
 - SAR for BAL-003-1 modification in work
 - Address minor errors in assumptions and process inefficiencies
 - 2016 Frequency Response Annual Analysis Report (FRAA), Sept 2016
 - Frequency withdrawal continues to be a predominant characteristic in the EI with 37 out of 84 events having a secondary nadir
 - Improved value B, CB ratio still much lower than other interconnections
 - 2017 State of Reliability (SOR) 2017, June 2017
 - Enhance measurements of frequency response to quantify the effects from changing resource mix
 - Modification to generator interconnection agreements
 - Increase awareness of frequency response challenges

- Essential Reliability Services and the Evolving Bulk-Power **System— Primary Frequency Response Notice** of proposed rulemaking (NOPR) was issued November 17, 2016
 - 60 Day Comment Period after Federal Register publication, Comments due January 24th, 2017
- The Federal Energy Regulatory Commission (Commission) proposes to revise its regulations to require all newly interconnecting large and small generating facilities, both synchronous and non-synchronous, **to install and enable primary frequency response capability** as a condition of interconnection

- The NOPR is proposing amendments to the *pro forma* Large Generator Interconnection Agreement (LGIA) and Small Generator Interconnection Agreement (SGIA) to require frequency response capability. The modifications include:
 - New large and small generating facilities, both synchronous and non-synchronous, to install, maintain, and operate equipment capable of providing primary frequency response
 - Governor or equivalent controls to be operated with maximum 5% droop and ± 0.036 Hz dead band settings
 - Timely and sustained response to frequency deviations, including provisions to prevent plant-level control equipment (a.k.a. “outer loop controls”) from inhibiting primary frequency response and resulting in premature withdrawal
 - Droop parameters to be based on nameplate capability with a linear operating range of 59 to 61 Hz
 - NOPR references current requirements in ISO-NE, MISO, CAISO and **also references PJM’s current requirements contained in Manual M14D, Section 7.1.1**

- The NOPR **does not** propose:
 - That the requirements apply to Nuclear units
 - That the requirements apply to existing units (requirements will only apply to new units & units requiring a revised ISA)
 - A headroom requirement on generating facilities
 - Any compensation for complying with the proposed requirements
- The Commission was seeking comments on whether the reforms proposed in the NOPR are sufficient to ensure adequate levels of primary frequency response, or whether additional reforms are needed (additional performance/ capability requirements for existing resources)

- **Agreed with NOPR on**
 - Requirements for Droop and Deadband Settings of 5 Percent and ± 0.036 Hz for New Generating Facilities
 - Requirements for Timely and Sustained Response
 - Requirement for Droop Parameters to be Based on Nameplate Capability with a Linear Operating Range of 59 to 61 Hz
 - Exemptions for Nuclear Units
 - Effective dates - The Commission proposed to apply the primary frequency response requirements to any new large or small generating facility that executes or requests the unexecuted filing of a LGIA or SGIA on or after the effective date of any final rule issued in this proceeding.
 - Not to Mandate Headroom
 - Not to Require Compensation
- **The IRC goes on to say**
 - Primary frequency response is essential for reliability and should be provided broadly across each interconnection.
 - PFR should be required of both newly interconnecting and existing generators
 - Requiring all new and existing units to have governor or other frequency control device response spreads the requirement over a large mix of resources and obviates the need for specific headroom requirements.

- August 18, 2017 FERC issued a request for Supplemental Comments
- Requested comments on items regarding performance characteristics and limitations of electric storage resources such as:
 - Droop
 - Deadband
 - Timely and sustained response
 - Wear and tear
 - Minimum step point

- Requested comments on disproportional costs and size limitations for small generating facilities considering:
 - Increasing market penetration
 - PJM's recent revisions to its Interconnection Agreements which require advanced inverters that include frequency response capability
- Comments due 21 days after published in the Federal Register – (not published as of 8/22/17)

- NERC Resources Subcommittee working on gathering data from individual BES generation owners for specific events to further analyze the Interconnections' frequency response
 - survey will request BES generator data for selected events
 - webinar held which discussed the specific data requested, format, and the logistics of submitting the survey form
 - Initiative has not started yet for Eastern Interconnection
- 6/20/17 NERC Lesson Learned
 - Two coal fired generators operating at approximately half load tripped due to low boiler furnace pressure while responding to a frequency excursion in WECC
 - Response was excessive due to the accumulated effects of plant modifications not represented in the unit control system tuning parameters
- If PFR continues to decline NERC could propose a system wide reliability standard
 - Could potentially require verification of governor settings and control system
 - Could potentially require performance standards

- Glossary of terms used in association with PFR – Posted on PFRSTF website under 7/25/17 Meeting Materials:
<http://pjm.com/committees-and-groups/task-forces/pfrstf.aspx>
- Reference Documents used in association with PFR – Posted on PFRSTF website under 7/25/17 Meeting Materials:
<http://pjm.com/committees-and-groups/task-forces/pfrstf.aspx>